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(54) Controlling machine operation with respect to consumable accessory units.

(57) Apparatus for controlling the use of consumable accessory units with machines where a memory device associated with each accessory unit holds information concerning the accessory unit, and circuitry in the machine acts in response to the information. The information includes (1) the classes of machines with which the accessory unit is intended to be used (the machine issues a signal if the machine is not within one of the intended classes); (2) the concentration of the contents of the accessory unit (the machine operation is controlled on the basis of the concentration); (3) an encrypted authorization code (the machine issues a signal if the decrypted code is not an authorized one); (4) the manufacturing lot of the accessory unit (the machine displays the lot number to the user); (5) the expiration date of the accessory unit (the machine issues a signal if the expiration date has passed); (6) a unique identification number to trigger the machine to compare a predetermined total number of permissible uses with the number of actual uses (the machine issues a signal when the accessory unit is deemed to be empty); (7) information concerning calibration of the machine (the electronic circuitry is calibrated in response to the information); (8) the range of permissible operating conditions for the machine in conjunction with the accessory unit (the machine displays the information for operator use); (9) the range of permissible uses of the accessory unit (the machine displays the permissible uses to the operator); and (10) the range of permissible quantities of material that may be added to the accessory unit (the machine displays the information to the user).

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Controlling Machine Operation With Respect to Consumable Accessory Units

Background of the Invention

This invention relates to storing information about the contents of a consumable accessory unit in a storage device associated with the unit, and then taking some action related to the unit or its contents based on the stored information.

It is known to incorporate a read-only memory (ROM) into a container for storing information. In Coffee et al., U.S. Patent 4,580,721, issued April 8, 1986, the container holds a pesticide, and the ROM stores the following information (col. 13, lines 31-64, and Table II): a "handshake security code" to restrict usage of the container; "acceptable flow rates" for the pesticide; a "voltage" setting for an electrostatic sprayer for the pesticide; the "container size;" the "chemical type" of the pesticide; and "the formulation date." Coffee also uses a programmable ROM in the container to hold and update a value representing the "liquid quantity" in the container. Coffee's container is used with spray machinery that includes electronics which control the spraying of the pesticide based on the information in the ROM.

Summary of the Invention

The general features of the invention relate to controlling the use of consumable accessory units with machines (e.g., analytical machines or chromatographs) where a memory device associated with each accessory unit contains information concerning the unit, its contents, or the manner in which it is to be used, and circuitry in the machine acts in response to or displays the information.

In one general feature of the invention, the machines comprise at least one of a plurality of different classes of machines adapted to receive consumable accessory units, each machine being arranged to take some action with respect to the contents of the accessory unit; the memory device stores information indicative of the predetermined classes of machines with which the accessory unit is intended to be used; and the machine circuitry issues a signal when the stored information indicates that the machine is not within those predetermined classes.

In another general feature of the invention, the machine performs an operation (e.g., a calibration operation) that depends on the concentration of the contents of a consumable accessory unit associated with the machine; the memory device holds information stating the concentration; and the machine circuitry controls the operation based on the concentration information.

In another general feature of the invention, the memory device holds information indicative of whether or not the accessory unit is authorized for use, the information being encrypted in accordance with a predetermined encryption scheme; the machine circuitry decrypts the information in accordance with the predetermined encryption scheme and issues a signal if the decrypted information indicates that the accessory unit is not an authorized one.

In another general feature of the invention, the memory device holds information indicative of the manufacturing lot of the accessory unit; the machine circuitry reads the information from the memory device and displays the information to a user of the machine.

In another general feature of the invention, the memory device holds information indicative of the expiration date of the accessory unit; the machine circuitry issues a signal when the expiration date has passed.

In another general feature of the invention, the memory device holds information uniquely identifying each accessory unit; the machine circuitry holds information indicative of the predetermined total number of possible uses, keeps track of the total number of uses of the accessory unit, and issues a signal when the total number of uses equals the predetermined total number.

In another general feature of the invention, for controlling the use of consumable accessory units with a machine for measuring a parameter where the machine requiring calibration, the memory device contains information concerning the timing of the calibration of the machine, and the machine circuitry controls the timing of the calibration based on the information.

In another general feature of the invention, the memory device contains information indicative of a range of permissible operating conditions for the machine in conjunction with the accessory unit, and the machine circuitry reads the information from the memory device and displays it to a user of the machine.

In another general feature of the invention, the memory device contains information indicative of a range of permissible uses for the accessory unit, and the machine circuitry reads and displays the information to the machine user.

In another general feature of the invention, the memory device contains information indicative of a range of permissible quantities of material that may be added to the accessory unit, and the machine circuitry reads and displays the information to the machine user.

Preferred embodiments include the following features. The memory device is a ROM that is connected electrically to the machine circuitry, and is permanently physically connected to the accessory unit by a tether. The circuitry includes a microprocessor controlled by a stored program. The machine is a blood analyzer, and the accessory unit holds electrolyte solution fluids for use in calibrating the circuitry (and associated sensors) in connection with performing blood analysis. The information concerning the timing of the calibration includes a value indicative of a time interval following a calibration after which another calibration will be considered. The information concerning the timing of calibration includes a value indicative of the frequency with which calibrations are to be performed relative to the frequency with which the machine makes measurements of the parameter. Alternatively, the machine is a gas or liquid chromatograph device, and the accessory unit is a chromatography column for use in conjunction with the device. When the circuitry issues one of the signals (for example, when the container is not intended for use on the machine), the accessory unit is prevented from being used on the machine.

The invention also features the consumable accessory unit itself, where the memory is arranged to be automatically read by the machine.

In preferred embodiments, the accessory unit has one or more chambers for holding substances and the memory device is attached to the chambers.

The invention insures that the correct fluids pack or column is installed in the machine; warns the user if the expiration date has passed; keeps track of how many uses remain for the fluids pack or column; prevents the user from attempting to use an empty fluids pack; ensures that the fluids pack will work properly with the analyzer even when the electrolyte concentrations are changed from the concentrations used in other packs; prevents the use of unauthorized fluids packs or columns; and enables the manufacturer of the packs to change the concentrations or the manufacturer of the columns to change the calibration without having to change the software in the machine.

Other advantages and features of the invention will become apparent from the following description of the preferred embodiments and the claims.

Description of the Preferred Embodiments

We first briefly describe the drawings.

Drawings

Fig. 1 is an isometric view of a fluids pack about to be inserted into a blood analyzer.

Fig. 2 is an isometric view of the fluids identification pod of Fig. 1 partially broken away.

Fig. 3 is a diagram of the contents of an EEPROM of the blood analyzer of Fig. 1.

Figs. 4, 5A-5d, and 6 are flow charts respectively describing the "check EEPROM security code," "read ROM cartridge and update EEPROM," and "update fluid consumption gauge" routines of the software controlling the blood analyzer of Fig. 1.

Fig. 7 is a flow chart of a calibration control routine.

Fig. 8 is an isometric view of a chromatography column about to be installed in a chromatograph.

Fig. 9 is a table of information that may be stored in the PROM pod for a chromatography column

Structure

Referring to Fig. 1, a blood analyzer 10 (of the kind described in Young et al., U.S. Patent 4,686,479, issued August 11, 1987 (assigned to the same assignee as this invention) has a bay 11 for holding a replaceable fluids pack 12. Four standard electrolyte solutions stored in four separate chambers 14 of fluids pack 12 are used to calibrate electronic circuitry 13 in connection with analyzing blood samples. The chambers 14 of fluids pack 12 are connected to analyzer 10 respectively via four fluid connections 16.

The four electrolyte solutions comprise two pairs, each pair containing two different concentrations of the same electrolyte (as required to calibrate electronic circuitry 13).

Information about pack 12 and the electrolyte solutions is stored in a fluids identification (FID) pod 18. A plastic tether 17 is securely attached at one end to FID pod 18 and at its other end to fluids pack 12. When fluids pack 12 is installed in analyzer 10, FID pod 18 is plugged into a FID pod connector 20. A cable 22 electrically connects FID pod 18 to electronic circuitry 13. Circuitry 13 includes at least one microprocessor 15 (with software in a programmable EPROM 29) which, among other things, fetches, processes and acts in response to the information stored in FID pod 18. Circuitry 13 also includes an electrically erasable programmable read-only-memory (EEPROM) 27, having 8,192 bytes of storage. EEPROM 27 holds information about the usage of pack 12 and is written and read by microprocessor 15.

Referring to Fig. 2, FID pod 18 contains a FID programmable read-only memory (PROM) 30 whose pins 32 are electrically connected to fingers 34 arranged along one edge of a printed circuit board 36. Fingers 34 make electrical contact with a corresponding set of contacts in connector 20.

PROM 30 is a 1024-bit bipolar PROM, programmed during the manufacturing process, whose storage is divided into 256 four-bit nibbles. The four-bit nibbles are arranged by pairs into 128 eight-bit bytes with even nibbles forming the high order four bits of each byte and odd nibbles forming the low order four bits of each byte. The 128 bytes are divided into two 64-byte sections which each contains a complete copy of the data stored within PROM 30. (The second copy of the data provides redundancy to reduce the chances of data loss.) A suitable data organization within each 64-byte section is as follows:

Byte	Function
0	Analyzer Type
1-7	Lot Number
8	Expiration Date, Month
9	Expiration Date, Year
10-13	Fluids Pack Number
14-61	Fluids Pack Concentrations Zone 1 Calibration Time Zone 2 Calibration Time Calibration Slippage Variable for Analysis Calibration Slippage Variable for Calibration
62-63	Checkword

Byte 0 contains a binary number from 0 to 255 which identifies the type of blood analyzer 10 with which this fluids pack is intended to be used. Bytes 1-7 together form a string of ASCII (American Standard Code for Information Interchange) characters identifying the manufacturing lot to which the contents of the fluids pack belong. Byte 8 identifies the final month after which the contents of the fluids pack are deemed to have expired. Byte 9 identifies the year of expiration. Bytes 10-13 contain a 24-bit fluids pack number (FPN), i.e., a serial number (ranging from 1 to 16,777,215) which uniquely identifies the pack among all others to be used with the type of analyzer designated in byte 0. The FPN is stored in an encrypted format which uses all 32 bits of bytes 10-13. Bytes 14-61 are used to store various parameters, including the respective concentrations of the electrolyte solutions, the calibration zone times and the slippage variables. Finally, bytes 62-63 contain a conventional two-byte CRC-16 checkword calculated from the other sixty-two bytes and capable of detecting more than 99% of all errors in the data.

Referring to Fig. 3, the 8,192 bytes of storage contained within EEPROM 27 are organized as 2,048 four-byte entries. The first entry in EEPROM 27 contains a security code 40. Each succeeding entry is arranged to store a three-byte decrypted FPN 42 and an associated one byte fluid consumption gauge number (FCG) 44 for a given fluids pack that has been or is being used on analyzer 10.

When a new fluids pack is first used with the analyzer, its FPN is stored in the next available entry in EEPROM 27 and its associated FCG 44 is set to 255 (to indicate that the fluid pack is full). Each time the fluids in the pack are used, the FCG is updated to reflect the number of uses of fluids remaining such that when the fluid pack is deemed to be enpty, its FCG will equal 0.

To determine the next available entry for a new fluids pack, EEPROM 27 is scanned to locate the first blank entry. Each time an FPN is stored, the next entry is cleared, and becomes the next available entry. After the last entry (2048) has been filled, the next FPN is stored in the second entry and EEPROM 27

contains the FPN's of the previous 2047 fluid packs used with the analyzer.

Operation

During operation of blood analyzer 10, as part of each blood analysis performed, the electronic circuitry 13 and associated sensors (not shown) are calibrated using electrolyte solutions drawn from fluids pack 12. The accuracy of the calibration operation requires that circuitry 13 know the true concentration values for the solutions contained in each pack and also requires that electrolyte solutions which have not been properly prepared or which no longer retain their potency not be used. To this end, the system software contained in the analyzer 10 includes procedures which, from time to time during the operation of the analyzer, use the information contained in FID PROM 30 to determine the concentration values and to verify that (1) the EEPROM 27 contains valid information; (2) the pack is intended for use with the type of analyzer in which it is installed; (3) the fluids in the pack are not being used beyond their expiration date; (4) the pack is not deemed to be empty; and (5) the data stored in FID PROM 30, on which these other procedures are based, has not been corrupted.

Specifically, referring to Fig. 4, when analyzer 10 is powered-up or reset, the security code 40 stored in EEPROM 27 is read (50) and compared (52) to the code value stored in the program EPROM 29, to assure that the EEPROM contains valid information. If the codes are not equal, an error condition (54) is indicated, all further analyses and other sequences are locked-out (56), and an appropriate error message is displayed (58) on screen 31. If, conversely, the codes are equal, the analyzer is activated for use.

Whenever analyzer 10 is turned on or reset, whenever each analysis, calibration, or other sequence is begun, and whenever a new fluids pack is installed in the analyzer, the information in FID PROM 30 is read and verified, and the information in EEPROM 27 may be updated in the following manner

Referring to Figs. 5A, 5B, 5C, 5D, the entire first copy of bytes 0 through 61 of data stored in FID PROM 30 is read (60), and the checkword for those bytes is computed (62). If the computed checkword does not equal (64) the checkword originally stored in bytes 62-63, then the first copy of the data is discarded and the second copy of the data is read (66) from PROM 30. A checkword is calculated (68) for this data and compared (70) with the checkword stored in bytes 62-63 in the second copy of the data. If the checkwords are again unequal (72), the user is locked-out (74, Fig. 5D) from performing any further analyses using the pack, and an appropriate error message is displayed (76, Fig. 5D) indicating that both copies of the data in the FID PROM 30 are wrong.

If, however, one or the other of the copies of the data is valid (78, 80) (that is, the computed checkword equals the stored checkword for that copy of the data), then the analyzer type (stored at byte 0) is compared to the actual analyzer type (stored in the program EPROM 29) (82). If the analyzer type is not correct (84), a lock-out occurs (74), and an appropriate error message is displayed (76).

If the analyzer type is correct, the FPN 44 stored in bytes 10-13 is decrypted (86), by a method that depends on the analyzer type. Referring to Fig. 5B, if decryption does not yield a valid FPN (87), lock-out occurs (74), and an appropriate error message is displayed (76). If decryption does yield a valid FPN (89), it is compared (88) to the current pack number (CPN) (i.e. the FPN of the pack used in the most recently performed analysis and stored in electronic circuitry 13); if they are equal, the pack has not been changed since the previous performance of the verification procedure.

If this is so (95), the expiration date (month/year) stored in bytes 8-9 is compared (90) to the current date to determine whether the pack has expired. If the current date is later than the expiration date (91), a warning message is displayed (92), and the user is given the option of proceeding or not; if the user chooses to proceed (93), the EEPROM entry 44 corresponding to the fluids pack is checked to see if the pack is to be construed as being empty, if it is, a lock-out occurs (74), and an appropriate error message is displayed (76); if it is not, the verification procedure has been completed, and the blood analysis can proceed.

If, on the other hand, the FPN is not equal to the current pack number (97), then the fluids pack has been changed since the previous performance of the verification procedure. If this is the case, the FPN retrieved from the FID PROM is compared with the FPNs stored in EEPROM 27 to determine whether this pack has previously been used with this analyzer. If it has (101), the FCG associated with the FPN is read from the EEPROM (100). If it indicates (103) that the fluids pack is to be construed as empty (see description below), lock-out occurs (74), and an appropriate error message is displayed (76).

If the FPN retrieved from the FID PROM is not found in the EEPROM (102), a new pack flag is set (104) which will result in writing a new FPN later (at 120).

If either the FPN was found in EEPROM 27 and the fluid pack was not empty (106), or the FPN was not

found (102), the expiration date stored in bytes 8-9 is compared to the current date (108, Fig. 5C), and, if the pack has expired (109), a warning message is displayed (110).

If either the pack has expired and the user nevertheless chooses to proceed (111) or the pack has not expired (113), all of the pertinent information derived from the FID PROM and the EEPROM is displayed, and the user is asked to accept or reject the fluid pack (114). If he does not accept the pack (115), a lock-out occurs (116), and the verification procedure terminates unsuccessfully.

If the user does accept the pack (117) and if the new pack flag is set (119), the FPN and its associated FCG are stored in the next available entry in EEPROM 27 (120). If the new pack flag is not set (118), the next step is to update standard concentrations (132). If the storage operation is successful (121) (if it is not (123), a lock-out occurs), the next entry in EEPROM 27 is cleared (122, Fig. 5D). If this entry is successfully cleared (125) (if it is not (127), a lock-out occurs), the FCG in the fourth entry behind the current entry is set to zero (i.e., empty). If this final operation on EEPROM 27 is successful (129) (if it is not (1270), an error message is displayed - 130), the concentration values of the electrolyte solutions stored in the electronic circuitry 13 are upated (132) with the values stored in bytes 14-61 in the FID PROM data for use in calibrating the electronic circuitry.

Referring to Fig. 6, during the lifetime of a fluids pack, its FCG must be updated as its fluids are consumed. This is done by maintaining a fluid counter (in the electronic circuitry 13) which is decremented each time an analysis is performed, i.e., a unit of fluids is consumed (134). The FCG has the capacity to resolve only 256 fluid levels, but a fluids pack may be designed to yield more than 256 analyses. Therefore, the FCG is not necessarily decremented each time the fluid counter is. Instead, a ratio, n, between the volume of the fluids pack and the capacity of the FCG is calculated. After the counter is decremented, a check is made to determine if the current value of the counter is evenly divisible by n; if it is not (135), the update procedure terminates. If it is (137), then the FCG associated with the FPN is read (138), decremented by one (140), and re-stored in EEPROM 27. If the gauge does not equal zero (143), the update procedure terminates. If the gauge has reached zero (145), indicating that the fluids pack is construed to be empty, a lock-out (146) occurs, and an appropriate error message is displayed (148). Note that the total number of possible uses of the pack counted by the fluids counter is only an estimate of when the fluids pack will be actually empty, based on the estimated amount of fluids used per analysis. When the counter reaches zero, there may still be a small amount of fluids remaining in the pack.

The analyzer also includes a feature to manage the frequency and times at which the analyzer is calibrated using the calibration fluids. By deferring calibration during periods when the module is not performing analyses, the rate of use of calibration fluids is reduced. In particular, the cost of the fluids per analysis tends to be equalized as between high and low volume (measured by number of analyses per day) users.

In the invention, calibration is triggered based on three conditions: (1) whether the analyzer is receiving requests to perform analyses, (2) the chemical stability of the fluids, and (3) the elapsed time since the previous calibration.

In general, analyzer 10 slips out of calibration (i.e., defers performing further calibrations) if more than a certain period of time has elapsed since the previous calibration and the analyzer has received no requests for analysis during that period. Slipping conserves fluids by reducing the frequency of calibrations; if the analyzer is not performing analyses, it is assumed not to need calibration.

Analyzer 10 includes software that allows the analyzer to slip automatically out of calibration mode based on defined calibration mode time zones (Zone 1; Zone 2, and Zone 3). The period of time the analyzer can spend in each of Zones 1 and 2 is stored in the PROM as Zone 1 Calibration Time and Zone 2 Calibration Time. For example the Zone 1 and Zone 2 calibration times may be 2 hours and 6 hours respectively. The analyzer shifts among the three zones based on the time elapsed since the last calibration and on the value of a Calibration Slippage Counter. The counter (stored in the analyzer) is (a) initialized to zero, (b) upon each analysis operation is incremented by the value of the Calibration Slippage Variable for Analysis (stored in the PROM; typical value is, e.g., 1), and (c) upon each calibration operation is decremented (but never below zero) by the value of the Calibration Slippage Variable for Calibration (also stored in the PROM; typical value is, e.g., 3).

Referring to Fig 7, specifically, in the Automatic Calibration Slipping Routine, a timer in the analyzer keeps track of the time elapsed since the previous calibration and a queue in the analyzer stores requests for a test to be performed. The analyzer continually checks the timer to see which time zone is in effect and checks the queue for any pending requests.

When operating in Zone 1, the module is fully calibrated and normal analyses may be performed. The analyzer stays in Zone 1 until the Zone 1 Calibration Time has elapsed. While the timer is within Zone 1 (52), the analyzer performs any requested analysis 54, increments the counter 56 by the Calibration

Slippage Variable for Analysis, and returns to check the timer and queue.

At the end of Zone 1, if the analyzer has performed one or more analyses 58, i.e., fluids have been used and hence the counter is greater than zero, the analyzer immediately calibrates 60, decrements the counter 62, resets the timer to zero, indicating the beginning of the Zone 1 period 64, and returns to check the timer. If, however, at the end of the time allotted for Zone 1, there have been no analysis requests 66, i.e., fluids have not been used and hence the counter remains at zero, the analyzer does not calibrate 68, zeroes the timer to indicate the beginning of the Zone 2 period 70, and returns to check the timer. Of course, the counter could still be greater than zero if it entered the most recent Zone 1 time period at a value greater than zero and in that case a calibration would be performed and the routine would return to begin a new Zone 1 time period. Further, if any of the instability conditions described below occurs during the time allotted for Zone 1, the analyzer immediately calibrates and returns to the beginning of the Zone 1 period.

When operating in Zone 2, the analyzer is fully calibrated but normal analysis is not allowed. In Zone 2, if the analyzer receives an analysis request 72, it performs the analysis with single point correction 74, and increments the counter 76 by the value of the Calibration Slippage Variable for Analysis. The analysis causes the analyzer to immediately calibrate 78 and to decrement the counter 80. Because the analyzer was just calibrated, it resets the timer to the beginning of the Zone 1 period 82, and returns to check the timer. If, however, there are no analysis requests during the Zone 2 time period 84, the module does not calibrate 86, resets the timer to the beginning of the Zone 3 period 88, and returns to check the timer. Further, if any of the chemical instability conditions described below occurs during the time allotted to Zone 2, the analyzer slips into Zone 3.

In Zone 3, the analyzer is uncalibrated and no analysis is allowed. The Zone 3 period 90 continues indefinitely until an analysis is requested. The analyzer must perform at least one calibration 92 before it can perform the analysis. Multiple calibrations may be necessary and if so are done automatically.

In Zone 3, if the time since the last calibration is within acceptable limits and the slope of the calibration curve is acceptable, then only one calibration is necessary. Otherwise, at least two calibrations are necessary and they must pass acceptable slope requirements. Once the analyzer is calibrated, it decrements the counter 94, resets the timer to the beginning of the Zone 1 period 96, and returns to check the timer.

Automatic calibration slipping will also be enabled after 24 hours of the analyzer being analytically idle, regardless of the counter value, thus conserving fluids. Among the instability conditions that may trigger automatic recalibration, regardless of the counter value, are: excessive Standard A drift, excessive temperature drift, and flow rate changes. All of these conditions are checked continuously by software in the analyzer 10.

Because it is the values stored in the PROM which control the calibration routine, the manufacturer of the fluids packs can control the calibration operations of the machine. The calibration counter has the effect of conserving fluids in low volume usage machines while maintaining calibration in high volume usage machines.

The invention helps to prevent a fluids pack from being used on a wrong analyzer, or used after it has expired, or used at all if it has an invalid serial number or its PROM data is corrupted, and reduces the use of calibration fluids. Accurate calibrations of the electronic circuitry are achieved. Use of the pack is prevented after the pack is deemed to be empty.

Other embodiments are within the following claims.

For example, referring to Fig. 8, in an analogous fashion a disposable chromatographic column 212 used in gas or liquid chromatography could have an attached PROM-based ID pod 218 which would contain information about the contents of the column and the kinds of machines and conditions under which it is to be used. When inserted in connector 220, pod 218 would control the use of column 212 (column 212 is inserted in a slot 214 of chromatographic device 200). As with the fluids identification pod of the first embodiment, some of the information stored in pod 218 would be used for identification and control; other information would be displayed (on a display 219) to allow the operator to make effective use of the column.

Referring to Fig. 9, the information stored in pod 218 could include numeric or alphanumeric fields as shown. Information about the column type 230 could include the material (glass, stainless stell), the active packing component (Carbowax 30, ion-exchange resin), and the support component (silica gel, plastic beads). The classes of compounds 232 which can be separated include primary compounds for which the column is very well suited and secondary compounds with which the column will work. The lot number 234 is similar to the lot number in the first embodiment. The date 236 could be the date of manufacture or the date of expiration. The conditions for use 238 could depend on whether the column is for gas chromatography or liquid chromatography. Sample sites 240 could include a range or a maximum. Calibration

information 242 could include retention time of standard compound at a given temperature, pressure, flow rate, and other conditions.

As with the first embodiment, the information stored in the PROM can be used to control the operation of the chromatograph. In addition, by displaying to the operator information indicating a range of permissible operating conditions or uses (e.g., the primary cluster of compounds or the conditions for use of the column presently installed) the user can operate the device in a manner consistent with the particular chromatograph.

Claims

1. Apparatus for controlling the use of consumable accessory units with a machine for measuring a parameter, said machine requiring calibration, characterized in that said apparatus comprises
a memory device associated with each said accessory unit and containing information concerning the timing of the calibration of said machine, and
circuitry in said machine for controlling the timing of said calibration based on said information.

2. The apparatus of claim 1 wherein said information concerning the timing of the calibration includes a value indicative of a time interval following a calibration after which another calibration will be considered.

3. The apparatus of claim 1 wherein said information concerning the timing of calibration includes a value indicative of the frequency with which calibrations are to be performed relative to the frequency with which the machine makes measurements of said parameter.

4. Apparatus for aiding the use of consumable accessory units with a machine characterized in that; said apparatus comprises
a memory device associated with each said accessory unit and containing information indicative of a range of permissible operating conditions for said machine in conjunction with said accessory unit, and
circuitry in said machine for reading said information from said memory device and displaying said information to a user of said machine, whereby said user takes some action with respect to said information to operate said machine.

5. Apparatus for aiding the use of consumable accessory units with a machine, characterized in that said apparatus comprises
a memory device associated with each said accessory unit and containing information indicative of a range of permissible uses for said accessory unit, and
circuitry in said machine for reading said information from said memory device and displaying said information to a user of said machine.

6. Apparatus for aiding the use of consumable accessory units with a machine, characterized in that said apparatus comprises
a memory device associated with each said accessory unit and containing information indicative of a range of permissible quantities of material that may be added to said accessory unit, and
circuitry in said machine for reading said information from said memory device and displaying said information to a user of said machine.

7. The apparatus of any of the preceding claims wherein said memory device is adapted for electrical connection to said circuitry in said machine.

8. The apparatus of any of the preceding claims wherein said memory device is permanently physically connected to said consumable accessory unit.

9. The apparatus of any of the preceding claims wherein said circuitry comprises a microprocessor controlled by a stored program.

10. The apparatus of any one of the preceding claims wherein said machine is adapted for analyzing a substance.

11. The apparatus of claim 10 wherein said machine performs gas chromatography and said consumable accessory unit is a gas chromatographic column.

12. The apparatus of claim 10 wherein said machine performs liquid chromatography and said consumable accessory unit is a liquid chromatographic column.

13. A consumable accessory unit for use with a machine that takes some action with respect to said accessory unit, said machine requiring calibration, characterized in that said accessory unit comprises
a memory device containing information concerning the timing of the calibration of said machine, said device being arranged to be read automatically by said machine.

14. A consumable accessory unit for use with a machine that takes some action with respect to the contents of said accessory unit, characterized in that said accessory unit comprises a memory device

containing information indicative of a range of permissible operating conditions for said machine in conjunction with said accessory unit, said device being arranged to be read automatically by said machine.

15. A consumable accessory unit for use with a machine that takes some action with respect to the contents of said accessory unit, characterized in that said accessory unit comprises a memory device containing information indicative of a range of permissible uses for said accessory unit, said device being arranged to be read automatically by said machine.

16. A consumable accessory unit for use with a machine that takes some action with respect to the contents of said accessory unit, characterized in that said accessory unit comprises a memory device for containing information indicative of a range of permissible quantities of material that may be added to said accessory unit, said device being arranged to be read automatically by said machine.

17. The consumable accessory unit of any of claims 13-16 wherein said memory device is arranged to be connected electrically to said machine.

18. The consumable accessory unit of claim 17 wherein said memory device comprises a read-only memory.

19. The consumable accessory unit of any of claims 13-18 wherein said memory device is attached to said accessory unit.

20. The consumable accessory unit of claim 19 wherein said memory device is attached to said accessory unit by a tether.

21. The consumable accessory unit of any of claims 13-20 wherein said accessory unit is a chromatographic column.

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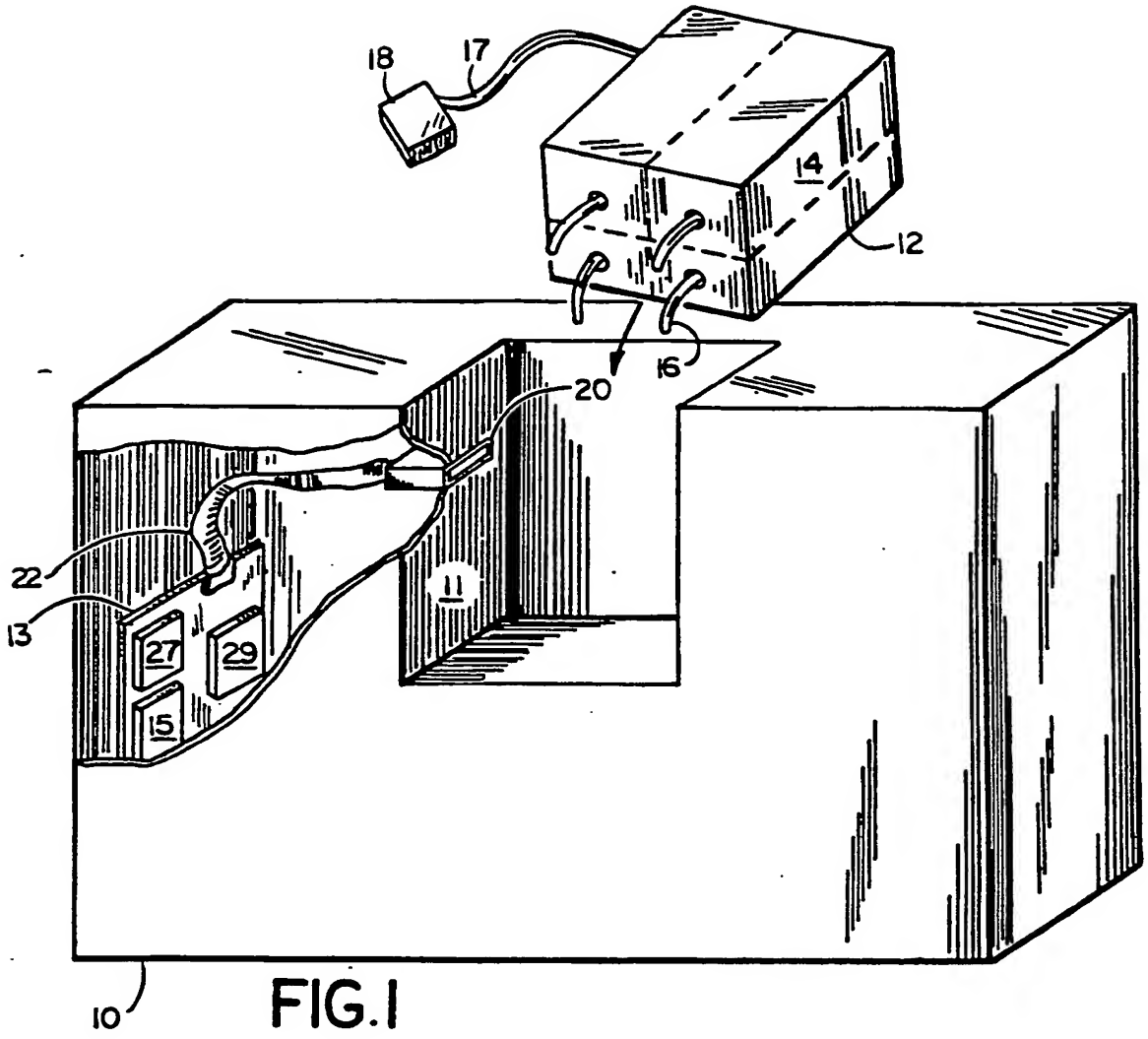

FIG.1

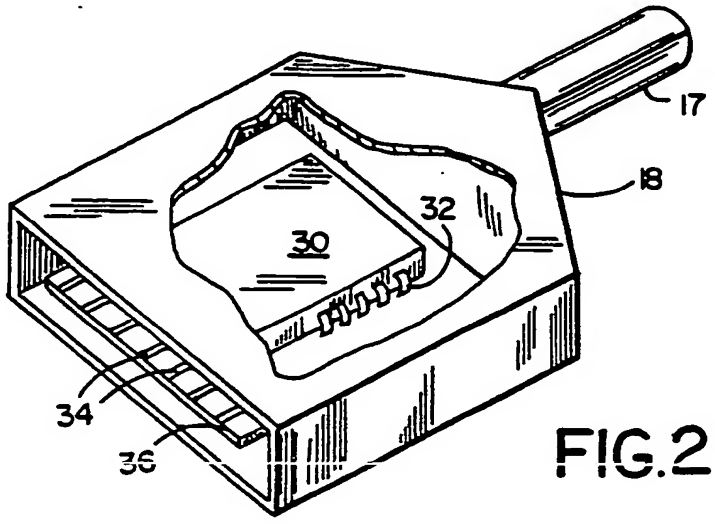

FIG.2

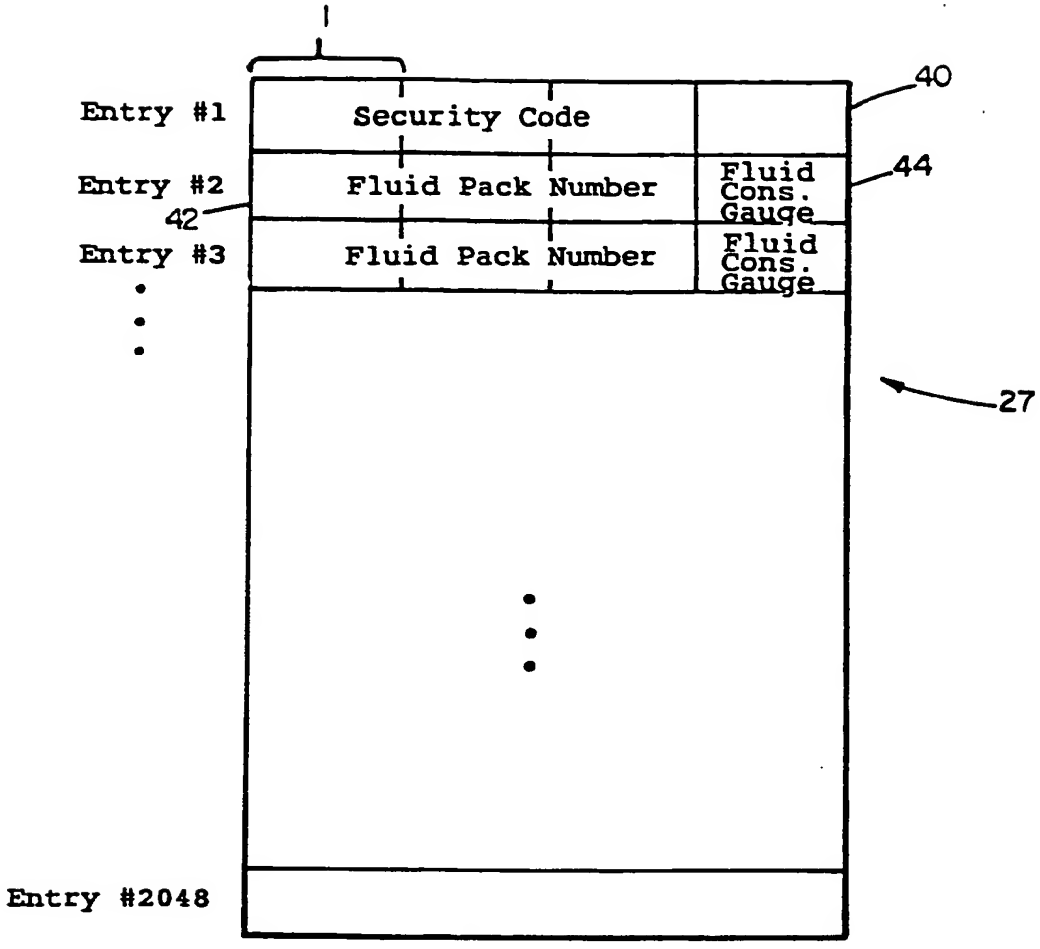
1
40
Entry #1
Security Code
Entry #2
Fluid Pack Number
Fluid Cons. Gauge
44
42
Entry #3
Fluid Pack Number
Fluid Cons. Gauge
27
Entry #2048

FIG.3

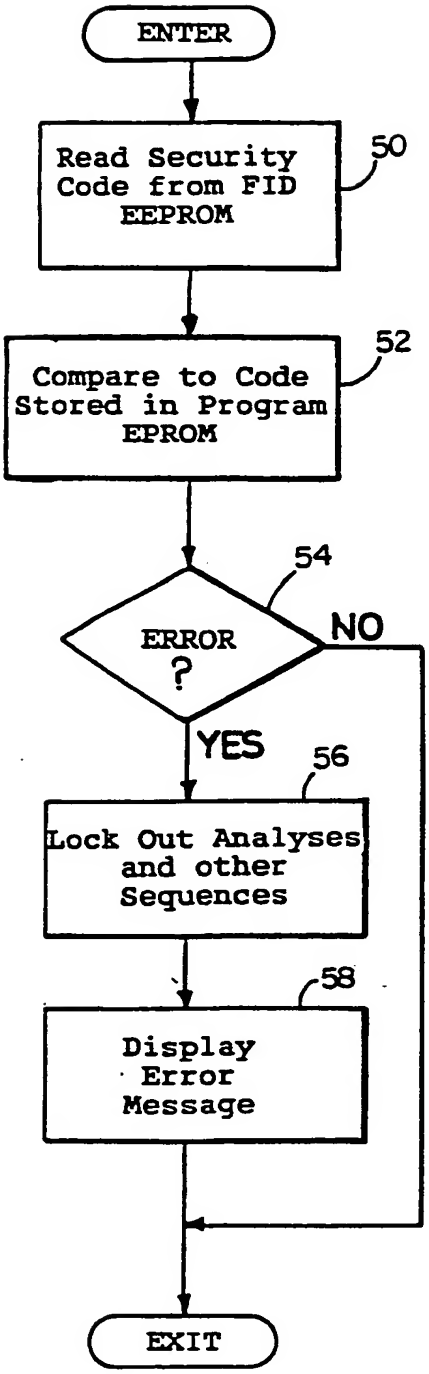
ENTER
Read Security Code from FID EEPROM
50
Compare to Code Stored in Program EPROM
52
ERROR ?
54
NO
YES
Lock Out Analyses and other Sequences
56
Display Error Message
58
EXIT

FIG.4

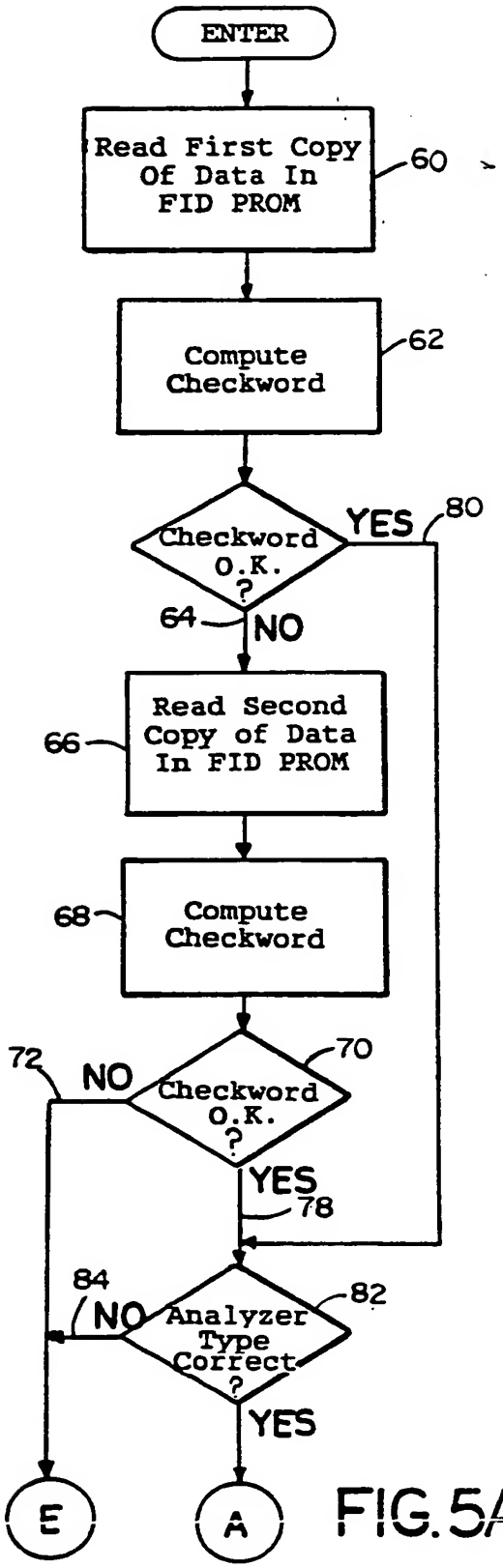
ENTER
Read First Copy Of Data In FID PROM
60
Compute Checkword
62
Checkword O.K. ?
YES
80
64
NO
Read Second Copy of Data In FID PROM
66
Compute Checkword
68
Checkword O.K. ?
70
72
NO
YES
78
Analyzer Type Correct ?
82
84
NO
YES
E
A

FIG.5A

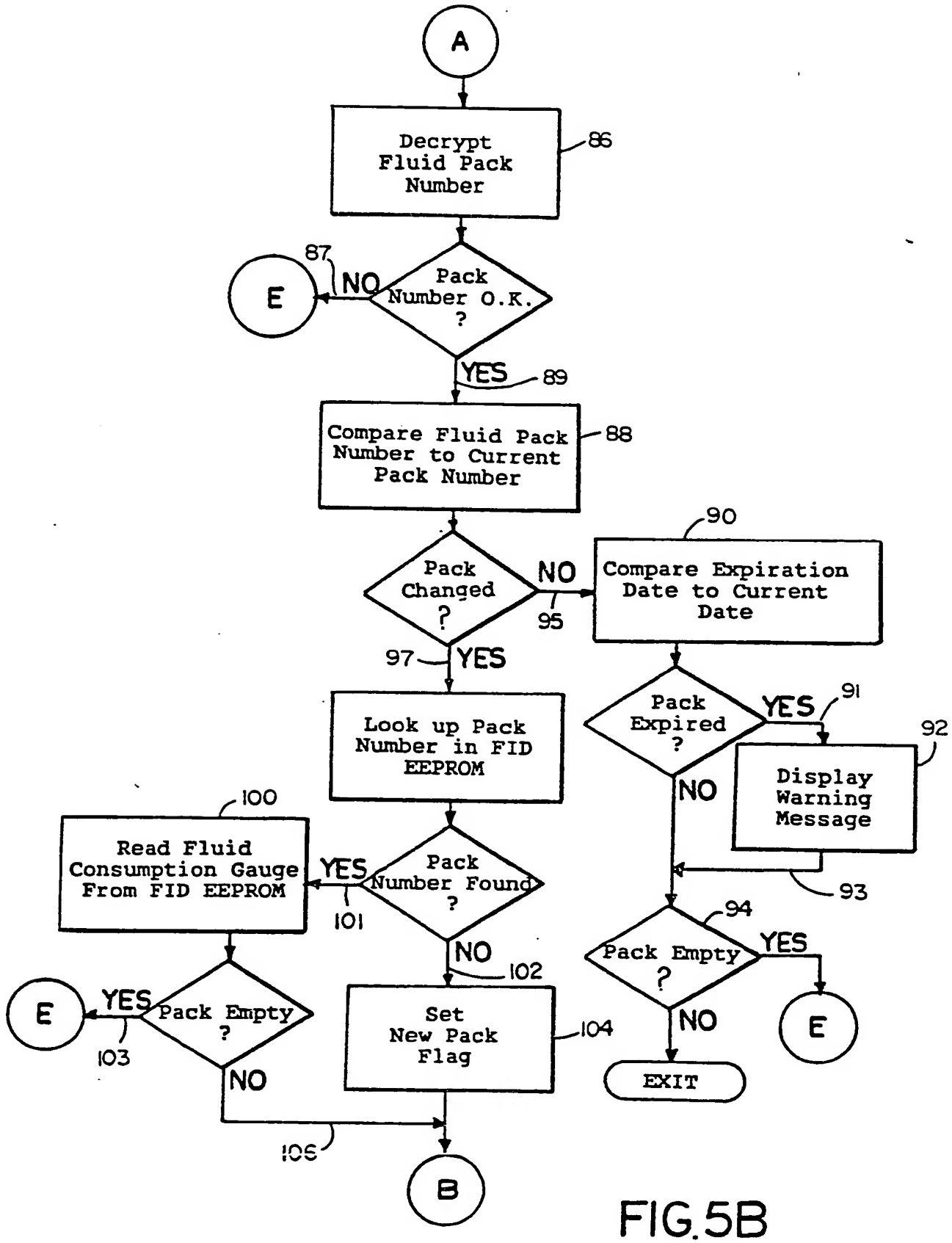

FIG.5B

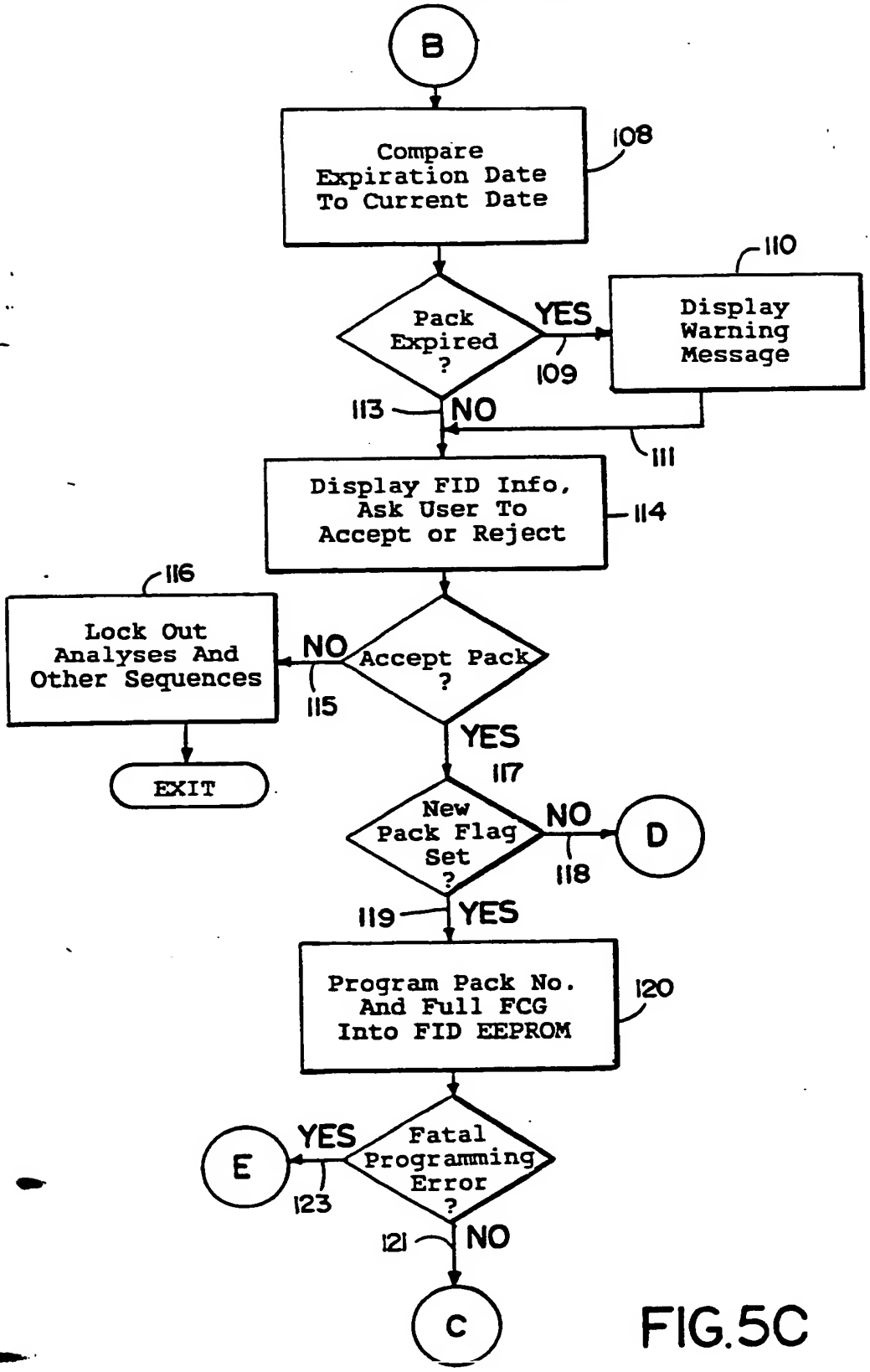
B
Compare Expiration Date To Current Date
108
Pack Expired ?
YES
109
Display Warning Message
110
113
NO
111
Display FID Info, Ask User To Accept or Reject
114
116
Lock Out Analyses And Other Sequences
NO
115
Accept Pack ?
YES
117
EXIT
New Pack Flag Set ?
NO
118
D
119
YES
Program Pack No. And Full FCG Into FID EEPROM
120
E
YES
123
Fatal Programming Error ?
121
NO
C

FIG.5C

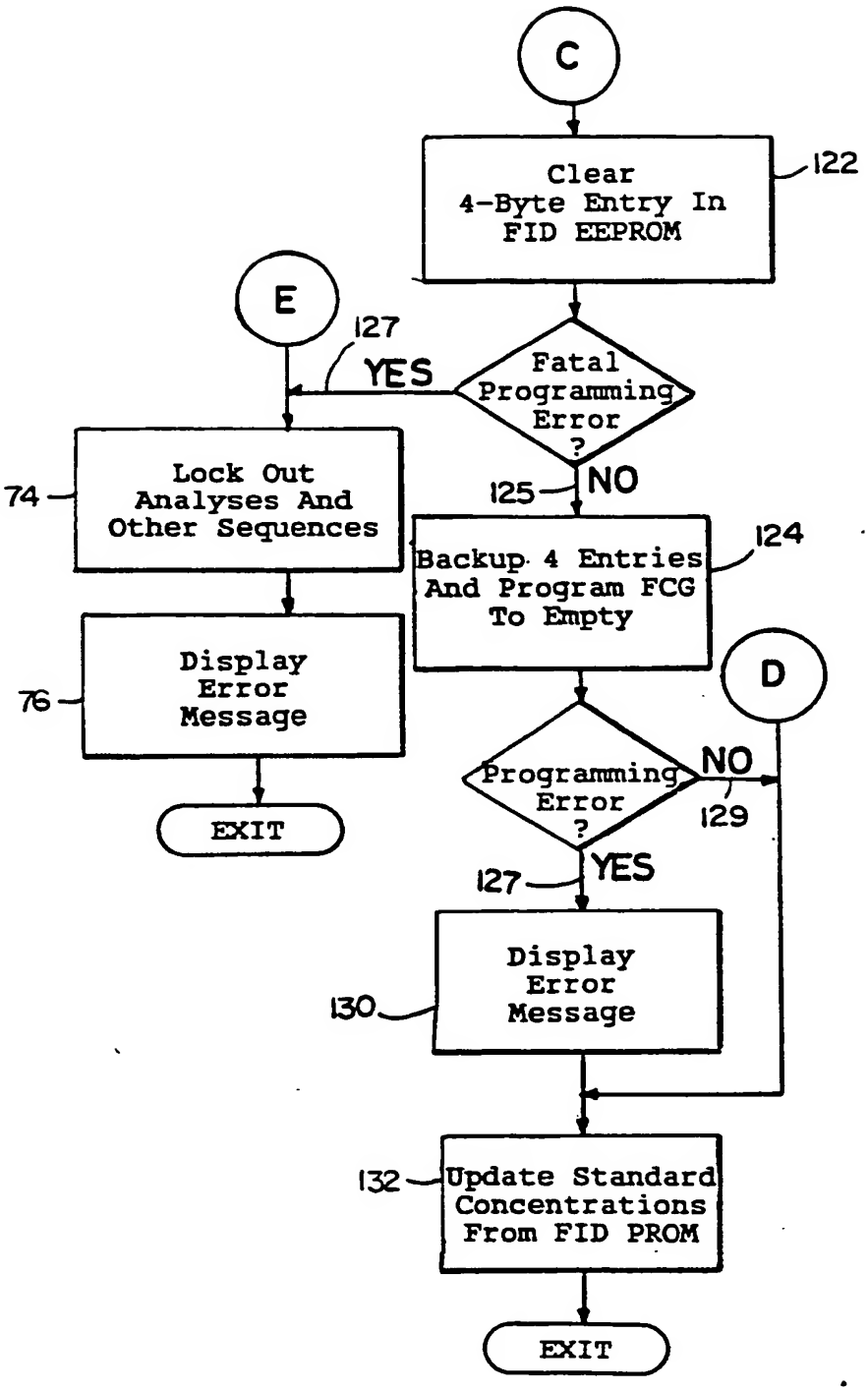
C
Clear 4-Byte Entry In FID EEPROM
122
E
127
YES
Fatal Programming Error ?
NO
125
74
Lock Out Analyses And Other Sequences
Backup 4 Entries And Program FCG To Empty
124
D
76
Display Error Message
Programming Error ?
NO
129
EXIT
127
YES
Display Error Message
130
132
Update Standard Concentrations From FID PROM
EXIT

FIG. 5D

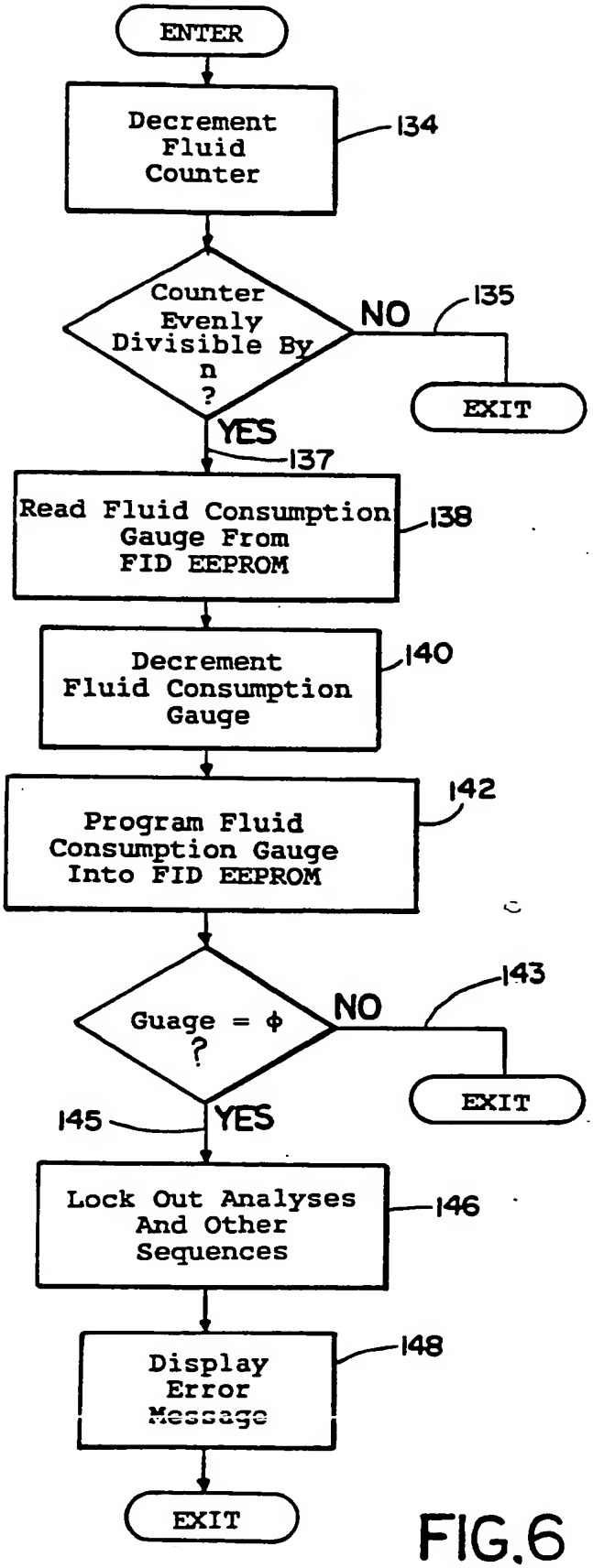
ENTER
Decrement Fluid Counter
134
Counter Evenly Divisible By n ?
NO
135
EXIT
YES
137
Read Fluid Consumption Gauge From FID EEPROM
138
Decrement Fluid Consumption Gauge
140
Program Fluid Consumption Gauge Into FID EEPROM
142
Guage = ϕ ?
NO
143
EXIT
145
YES
Lock Out Analyses And Other Sequences
146
Display Error Message
148
EXIT

FIG.6

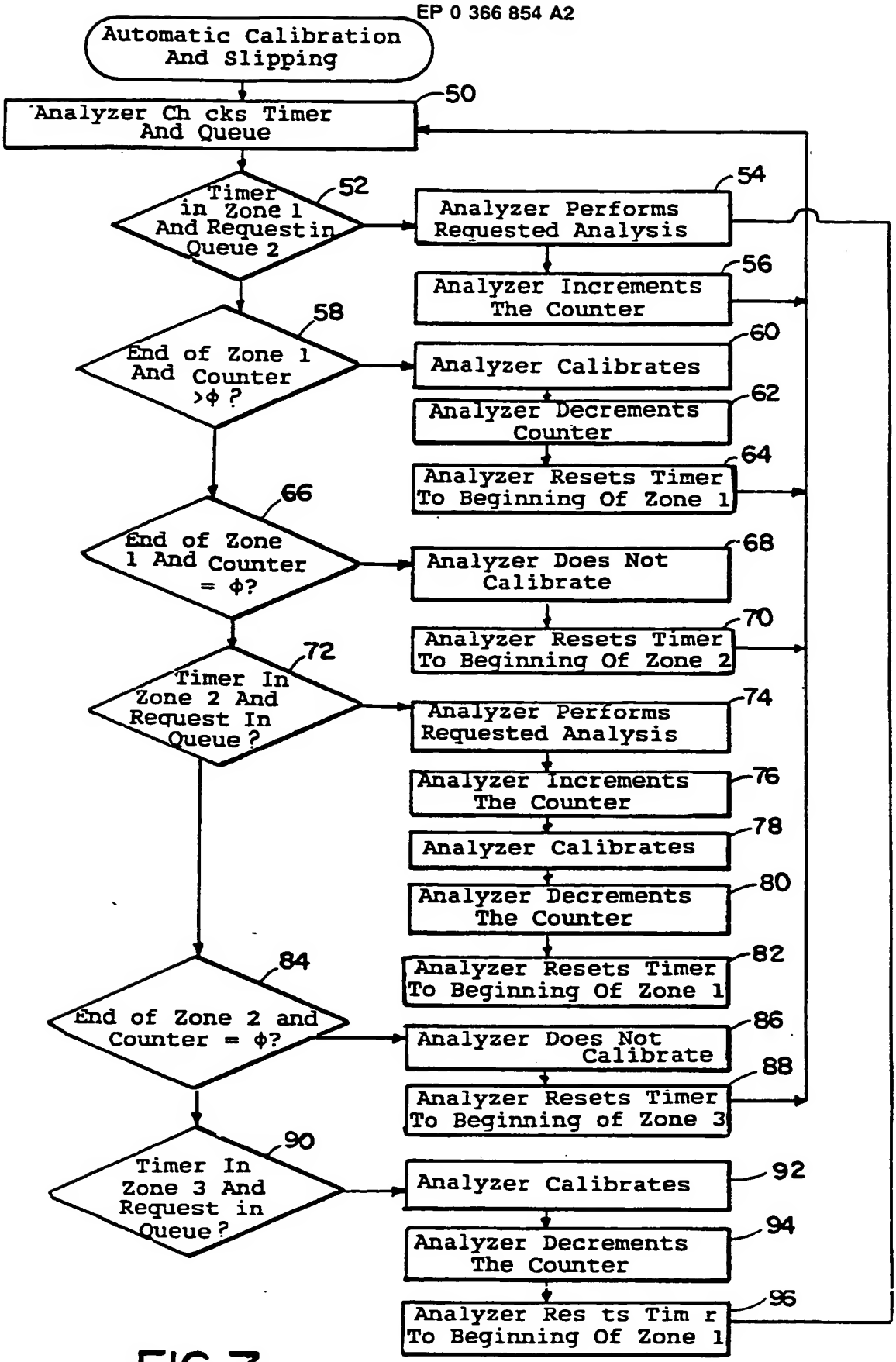

FIG. 7

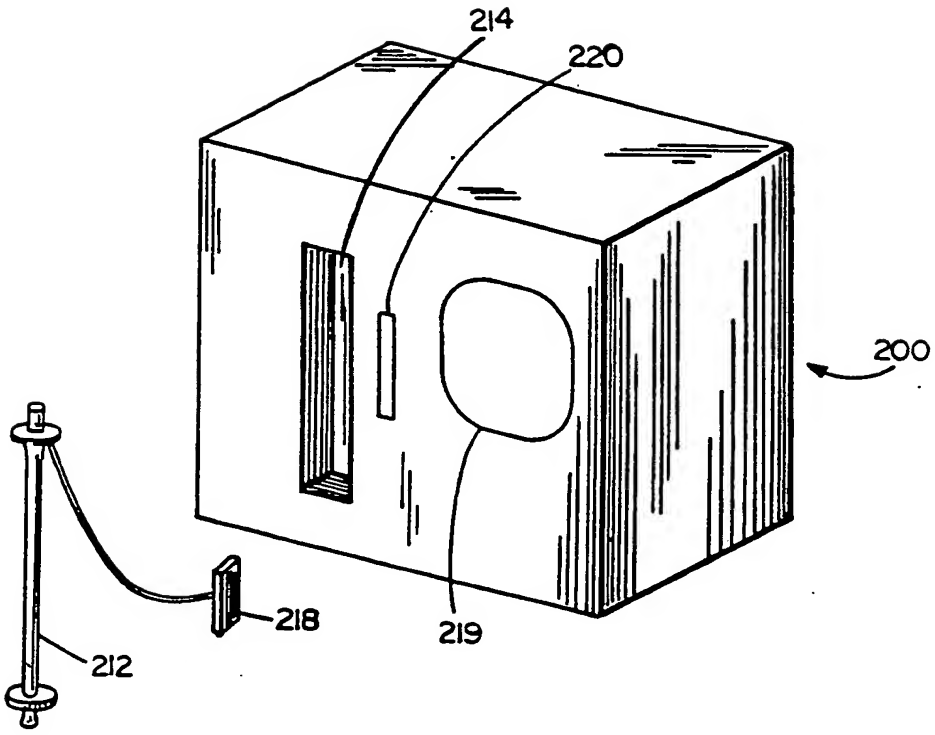

FIG.8

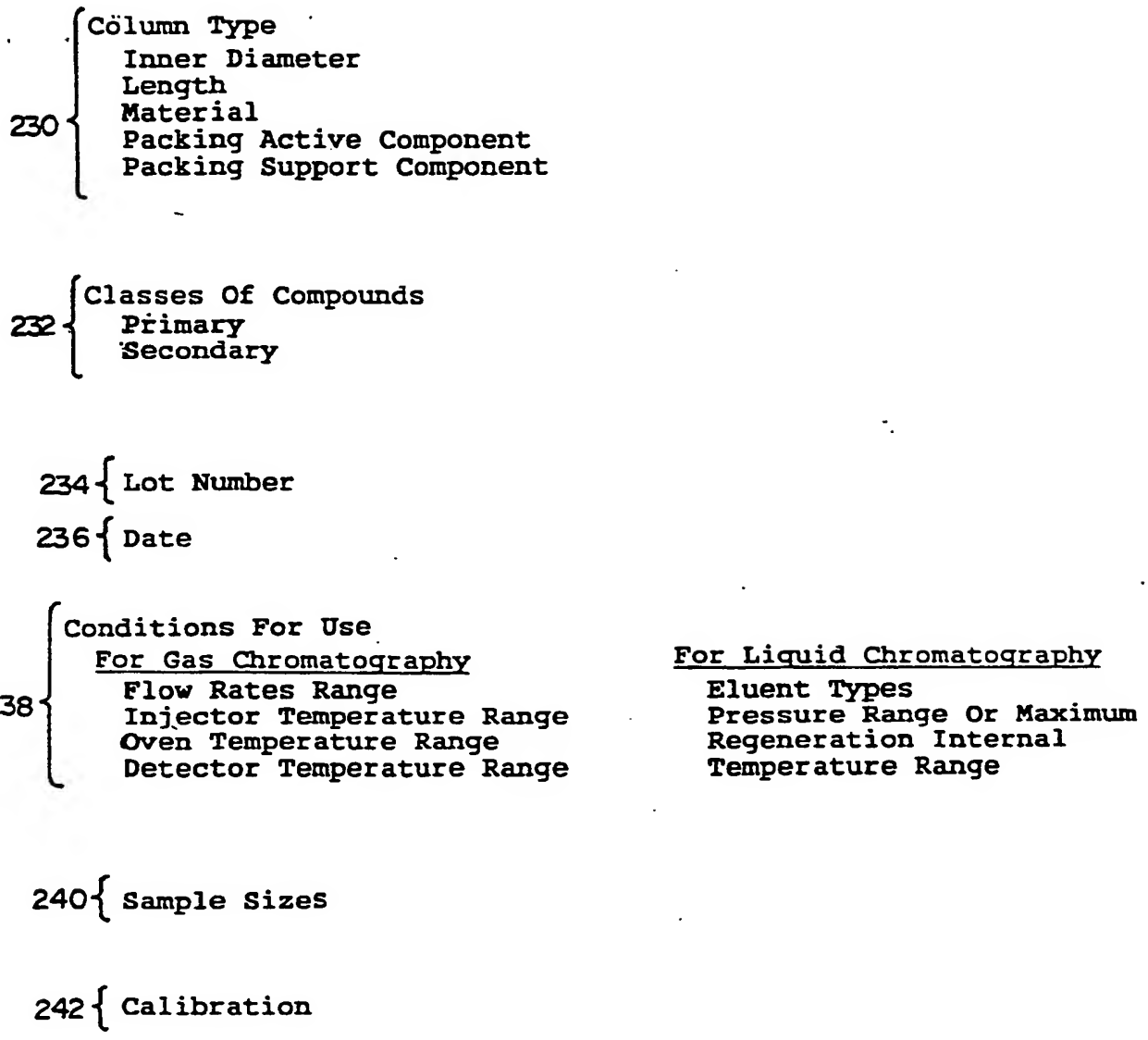
Column Type
Inner Diameter
Length
Material
Packing Active Component
Packing Support Component
230
Classes Of Compounds
Primary
Secondary
232
234
Lot Number
236
Date
Conditions For Use
For Gas Chromatography
Flow Rates Range
Injector Temperature Range
Oven Temperature Range
Detector Temperature Range
For Liquid Chromatography
Eluent Types
Pressure Range Or Maximum
Regeneration Internal
Temperature Range
238
240
Sample Sizes
242
Calibration

FIG.9

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Rechtsanwalt & Patentanwalt Dipl.-Phys. Dr. jur. U. HEIDRICH Franziskanerstrasse 30
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(54) Controlling machine operation with respect to consumable accessory units.

(57) Apparatus for controlling the use of consumable accessory units with machines where a memory device associated with each accessory unit holds information concerning the accessory unit, and circuitry in the machine acts in response to the information. The information includes (1) the classes of machines with which the accessory unit is intended to be used (the machine issues a signal if the machine is not within one of the intended classes); (2) the concentration of the contents of the accessory unit (the machine operation is controlled on the basis of the concentration); (3) an encrypted authorization code (the machine issues a signal if the decrypted code is not an authorized one); (4) the manufacturing lot of the accessory unit (the machine displays the lot number to the user); (5) the expiration date of the accessory unit (the machine issues a signal if the expiration date has passed); (6) a unique identification number to trigger the machine to compare a predetermined total number of permissible uses with the number of actual uses (the machine issues a signal when the accessory unit is deemed to be empty); (7) information concerning calibration of the machine (the electronic circuitry is calibrated in response to the information); (8) the range of permissible operating conditions for the machine in conjunction with the accessory unit (the machine displays the information for operator use); (9) the range of permissible uses of the accessory unit (the machine displays the permissible uses to the operator); and (10) the range of permissible quantities of material that may be added to the accessory unit (the machine displays the information to the user).

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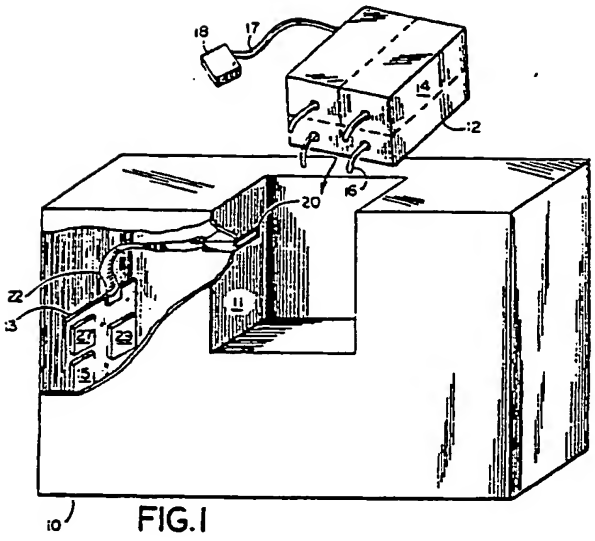

FIG.1

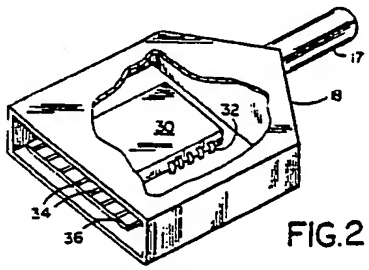

FIG.2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 10 1626

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	EP-A-214666 (OMRON TATEISI ELECTRONICS CO.) * the whole document *	14, 15	G05B19/12
Y		1-3, 7-9, 13	
Y	US-A-4678755 (HIROO SHINOHARA ET AL.) * the whole document *	1-3, 7-9, 13	
Y	EP-A-142688 (INDESIT INDUSTRIA ELETTRODOMESTICI ITALIANA SPA) * the whole document *	4-6	
Y	GB-A-2185130 (TOKYO KEIKI COMPANY LTD) * the whole document *	4-6	
Y	FR-A-2600166 (RHONE POULENC RECHERCHES) * the whole document *	10-12, 16-21	
Y	TECHNISCHE MITTEILUNGEN KRUPP. no. 1, June 1988, ESSEN DE pages 3 - 14; PEGELS Hans: "Flexible manufacturing : Development of tooling systems and peripherals" * pages 3 - 14 *	10-12, 16-19, 21	TECHNICAL FIELDS SEARCHED (Int. Cl.5) G05B G01N
Y	FR-A-2572326 (GAZ DE FRANCE ET SAURON SA) * the whole document *	20	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 SEPTEMBER 1990	HAUSER L.E.R.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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